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(56) Documents cited
GB 2190268 A GB 1445914 A GB 1317510 A
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(71) Applicant
Tecnocad Limited

(Incorporated in Ireland)

Finisklin Industrial Estate, Sligo, Ireland

(72) Inventors
Kenneth Carroll
Patrick Neary

(74) Agent and/or Address for Service
Marks & Clerk
57-60 Lincoln's Inn Fields, London, WC2A 3LS, United Kingdom

# (56) Design of articles having inter-related parts

(57) An apparatus for design of articles such as a mould has a knowledge design database 20, a design controller 21 and a user interface 22 for generation of items forming part of an article, parameters for the item being selected according to control rules within the database 20 and user inputs at the interface 22. The design controller 21 may output signals to a drawing control module 24, a machine control module 26, a materials listing module 28 or a solid model definition module 30. The wide range of outputs is made possible by the fact that a designed model is stored as a set of defined items which are each independent designs in their own right, and are interrelated.

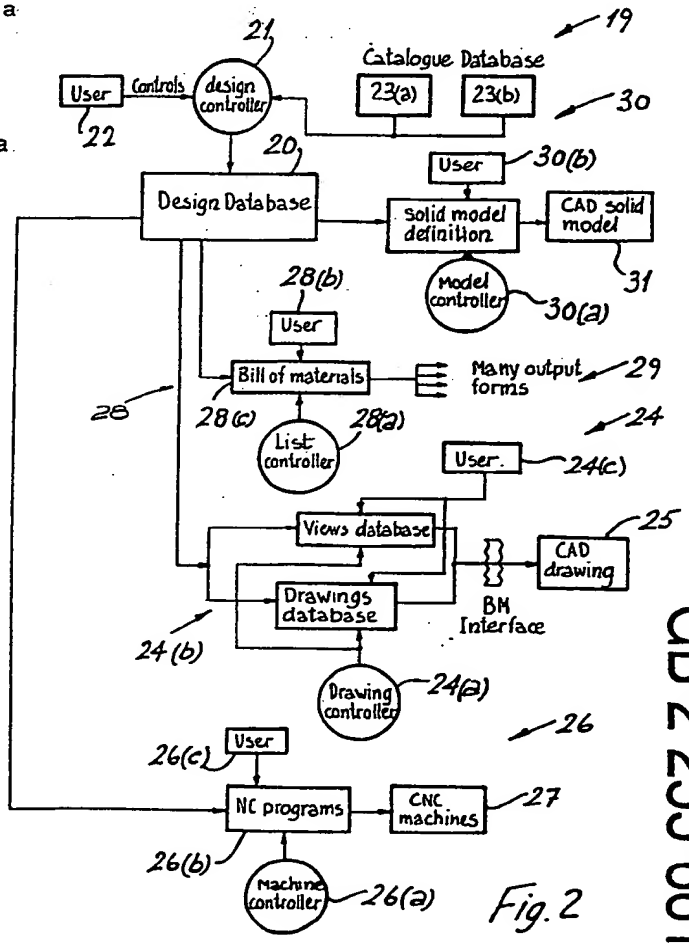


Fig. 2

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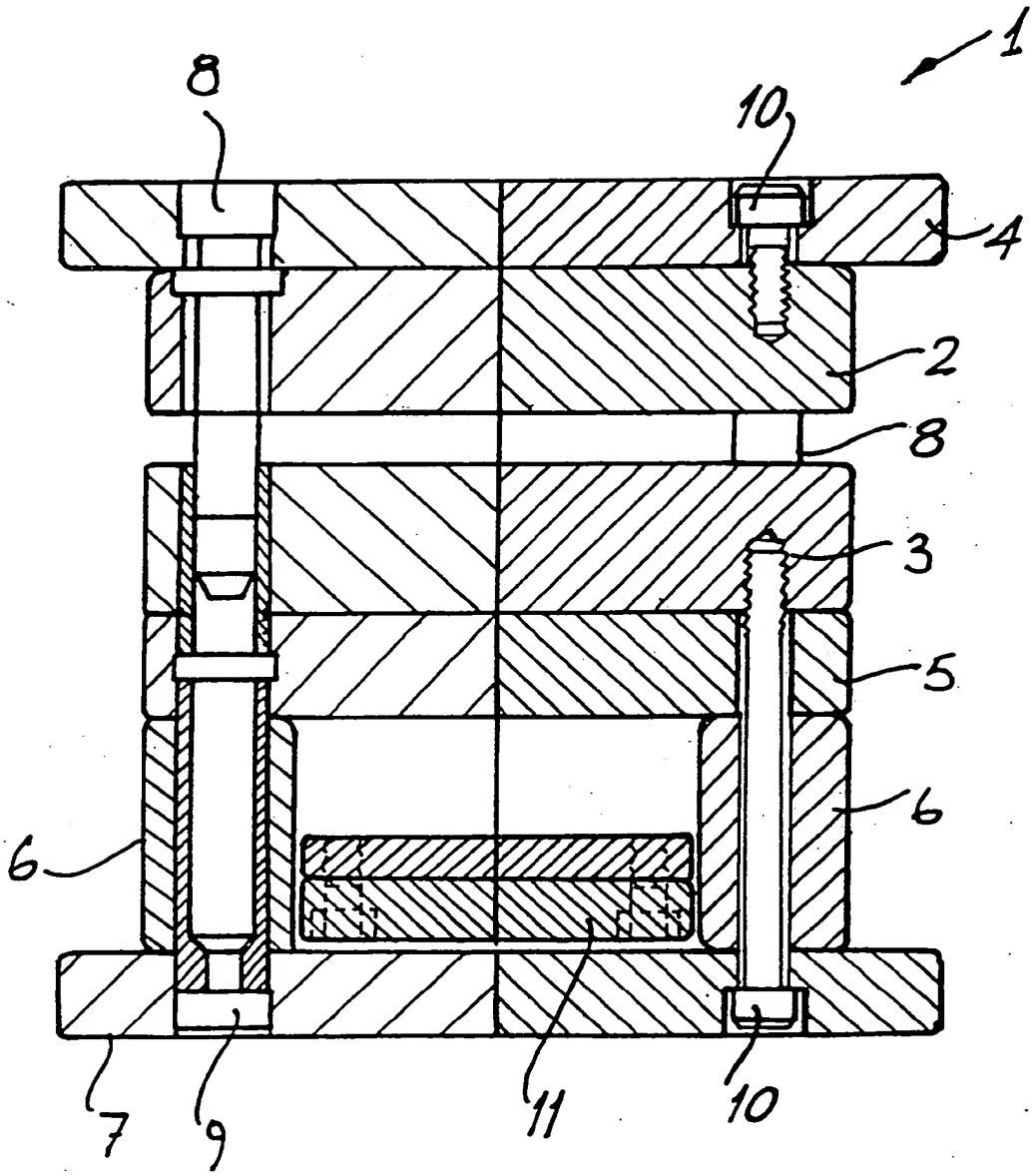


Fig. 1

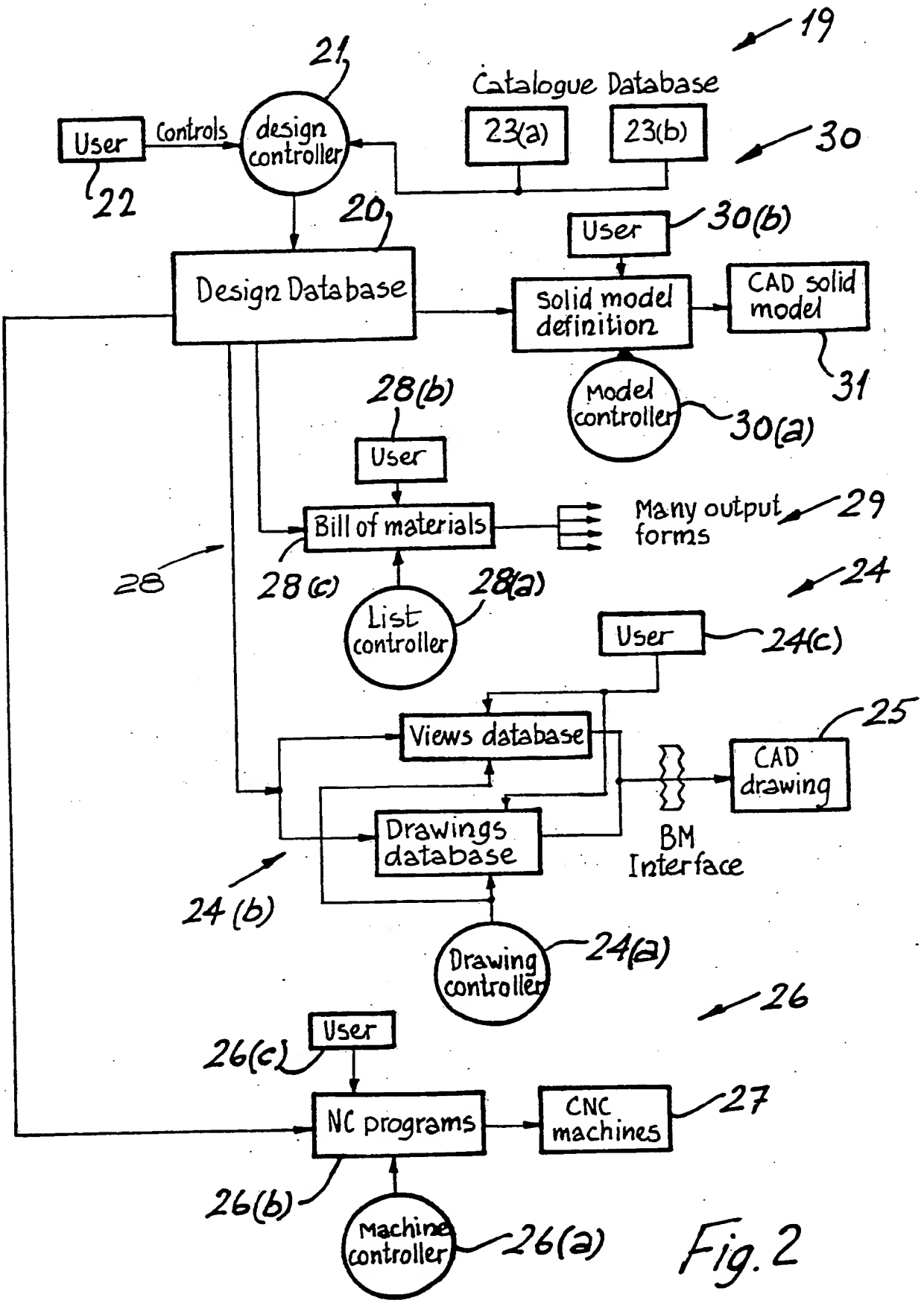


Fig. 2

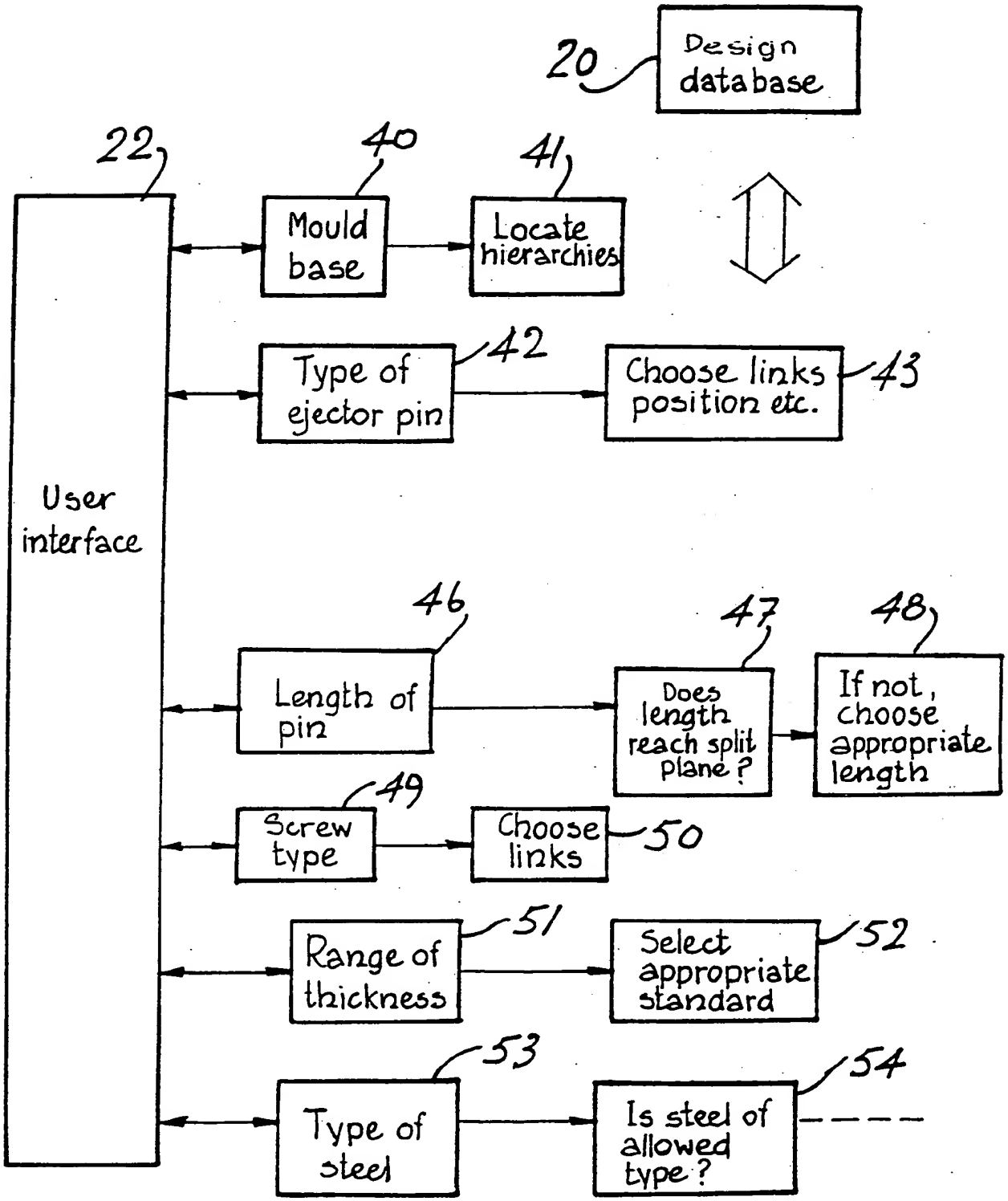


Fig.3

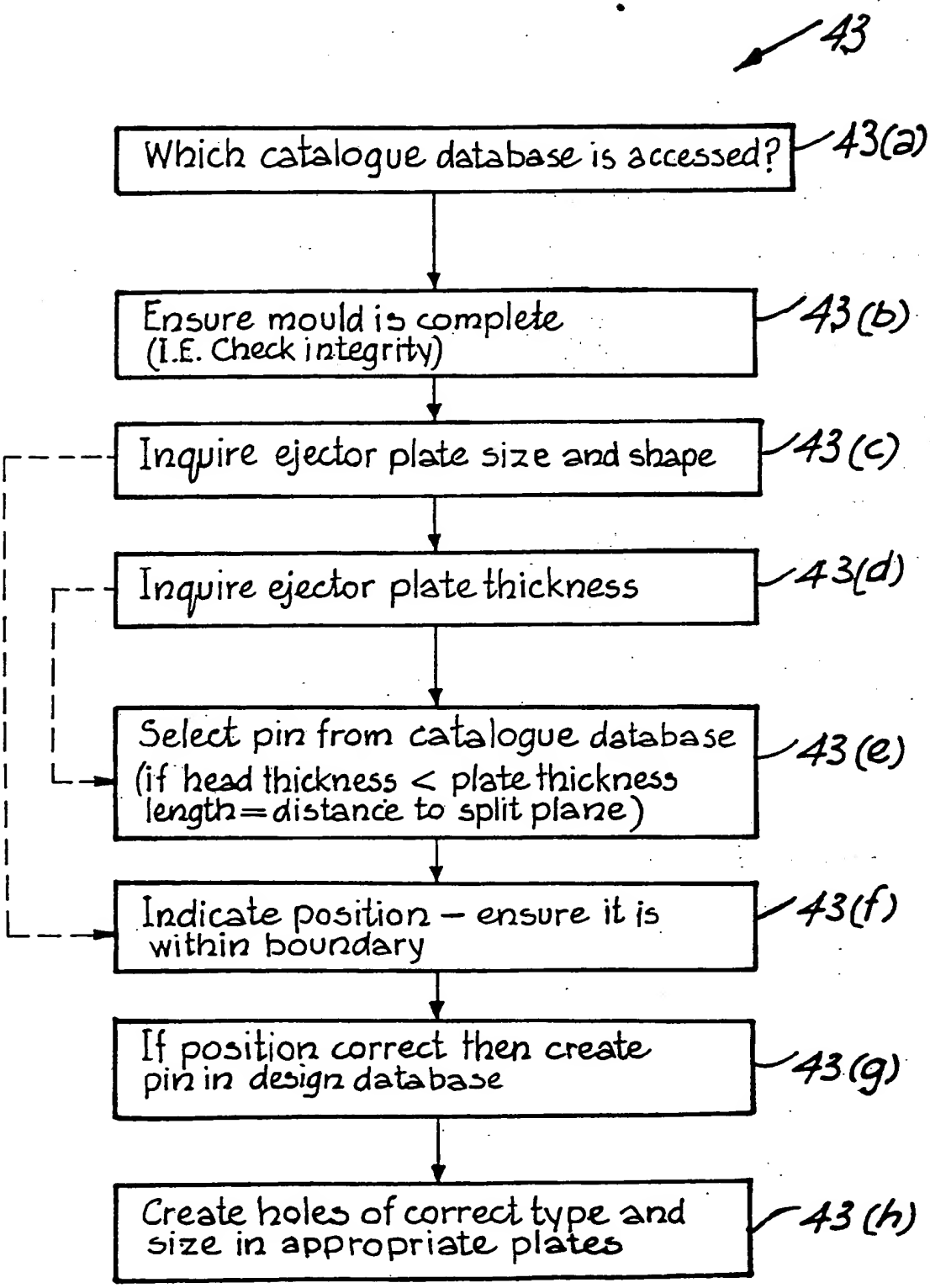


Fig.4

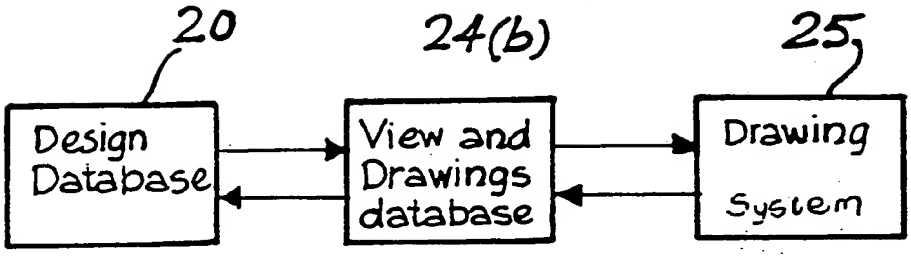


Fig. 5(a)

| Design Item | Drawing item |
|---|---|
| 9 | 27 |
| 9 | 93 |
| 9 | 1014 |
| | |
| | |

Fig. 5(b)

"A design apparatus"

The invention relates to the design of articles in which there are a number of interrelated parts such as moulds which have various parts such as clamp plates, cavity plates, ejector pins, etc. The invention is more particularly directed towards the design of articles which are relatively complex and where the interrelationship of the various parts is complex, moulds being a typical example. The invention would also apply to the design of articles such as vehicle engines.

At present, systems generally referred to as Computer Aided Design - Computer Aided Manufacturing (CAD-CAM) are available to assist in the design of articles. Such systems either generate 2-dimensional or 3-dimensional drawing outputs. If 3-dimensional, the output may be in a crude format such as a "wire frame" type in which lines in a third dimension are always straight and simply interconnect lines for the other two dimensions. Systems which provide an improved output include "surface modelling" or "solid modelling" outputs which are truly 3-dimensional. For example, United States Patent Specification No. 4,736,306 (Christensen et al) describes a

system for conversion between a boundary representation model and a solid model.

In general, presently available design systems vary only in the manner in which drawings are presented, there being a wide range of complexity and required processing power. For example, solid modelling requires considerably more processing power and memory than surface modelling. However, these systems operate on the same basic principal of receiving a drawings input either from a graphics terminal or from a measuring machine (such as described in UK-A-2,210,707). The drawing systems then manipulate the received drawings to provide the various views and allow addition of lines to define a designed article in more detail. All lines in the drawing representation are interrelated in space so that, for example, they all move together when changing from a perspective view to a side view.

A problem with such systems is that they have limited scope of use as they merely provide for automated drawing and rely entirely on input of drawing data. Accordingly, they only reduce by a relatively small amount the lead time in design of an article such as a mould. A considerable amount of additional time is required for generation of inputs for the drawing system, for generation of bills of materials, of machine control programs for machining of the article and various other work.

The invention is directed towards providing a design apparatus which has a considerably broader scope of application than presently available drawing apparatus to substantially reduce the time required for both design and manufacture of an article.

According to the invention, there is provided an apparatus for design of articles, the apparatus comprising:-

a knowledge design database defining items potentially incorporated in design of an article, the database storing the item parameters including permissible dimensions, attributes, links and a description, the database further storing control rules for selection of parameters for each item;

a user interface;

a storage device;

a design controller connected to the design database, the user interface, and the storage device and comprising means for directing display at the user interface of prompts for user interactive input of item parameters; means for assigning a design identification code to each item; means for verifying user inputted parameters; and means for selecting parameters according to the design

database and user inputs, and means for directing storage of selected parameters for all items for a designed article in the storage device;

a knowledge drawings database comprising stored drawing output signals associated with item parameters; and

a drawing controller connected to the design database and to the drawing database and comprising means for assigning a drawing identification code to each item cross-referenced with a design identification code, and means for converting item parameters to a drawing control output by reference to the drawing database.

In one embodiment, the drawing controller interactively maintains a table of identification codes for cross-referencing design and drawing identification codes for items.

Preferably, the items include both solid parts and empty space within an article.

In another embodiment, the apparatus further comprises a database of machine control programs, and a machine controller comprising means for retrieving machine control programs in response to item parameters for generation of machine control signals.

In a further embodiment, the apparatus further comprises a database of solid model definition programs and a solid model definition controller comprising means for retrieval of items relating to solid parts and selection of the programs in response to the item parameters for generation of solid model definition signals.

In a still further embodiment, the apparatus further comprises a database of bill of material listing data and a listing controller comprising means for retrieval of items relating to a bill of material and selection of data according to the item parameters for generation of bill of material printing signals.

The invention will be more clearly understood from the following description of some preferred embodiments thereof, given by way of example only with reference to the accompanying drawings in which:-

Fig. 1 is a diagrammatic split cross-sectional view of a mould which is typical of the type of article designed by the apparatus of the invention;

Fig. 2 is a drawing of an apparatus of the invention;

Fig. 3 is a flow diagram illustrating operation of a design controller of the apparatus;

Fig. 4 is a more detailed flow diagram illustrating operation of the apparatus; and

Figs. 5(a) and 5(b) are a flow diagram and a table respectively showing operation of a drawing controller.

Referring to the drawings, and initially to Fig. 1, there is illustrated a mould which is typical of the type of article which is designed with an apparatus of the invention. The mould 1 comprises a cavity plate 2 in a fixed part of the mould for engagement with a core plate 3 in a movable part of the mould. A clamp plate 4 is connected to the cavity plate 2 and a support plate 5 is connected to the core plate 3. The mould 1 also includes risers 6, a clamp plate 7, guide pillars 8, liners 9, cap screws 10 and an ejector set 11. Those skilled in the art will appreciate that the mould includes various other parts, not shown, such as cooling/heating channels, ejector pins, sleeves and blades.

It will be appreciated that there is a complex interrelationship between the various parts of the mould 1, for example, the length of pillar is related to the length of sleeve and the dimensions of the plates. Similarly, the thickness is determined by the dimensions of the risers, the forces which would be involved and various other factors.

Referring now to Fig. 2, there is illustrated a design apparatus of the invention for design of such articles. The design apparatus 19 comprises a design database 20 which is structured in an object-oriented manner. Object hierarchies stored in the database are structured from items, and the objects chosen for each item are parameters of the item. An item may be a screw, a clamp plate or an ejector pin, in which case it would be similar to a "part" of the mould. However, in addition, an item may be empty space such as a through-bore for reception of a sleeve or any type of cut-out.

The parameters for each item include features, attributes, links, a design identification code, and dimensions. Features would generally be a simple descriptive title for the item such as screw, clamp plate, etc. Attributes would include subordinate or part-of relationships such as a through-bore being subordinate to an ejector pin. Links would include codes which link the item with other items of a similar type such as various different screws. In this example, a screw of one type would have a code which links it with a screw of another type or of a similar type used in the same mould. A design identification code for each item is unique and the dimensions would generally include diameter, length, thickness, etc.

The design database 20 includes object hierarchies for selection of these parameters using a combination of user

inputs and control rules. This is described in more detail below. The design controller 21 is connected to a user interface 22 which, in this embodiment, is a graphics terminal for display of both drawing and text panels simultaneously on a screen. The design controller 21 is connected to a number of catalogue databases indicated 23(a) and 23(b). These databases are computerised versions of catalogues prepared by manufacturers of components for articles. In this case, each database 23 is for a particular manufacturer of mould components. The apparatus 19 also includes various output modules including a drawing control module 24, a machine control module 26, a materials listing module 28 and a solid model definition module 30, all of which are connected to the design database 20.

The drawing control module 24 includes a drawing controller 24(a) connected to drawing databases 24(b) and to a user interface 24(c). Output signals of the drawing control module 24 are directed to a conventional drawing system 25 via a "BM" interface.

The machine control module 26 includes a machine controller 26(a) connected to a database 26(b) of machine programs and to a user interface 26(c). Output signals of the machine control module 26 are directed to various conventional CNC machines 27.

The materials listing module 28 includes a material list controller 28(a) connected to a user interface 28(b) and to a listing database 28(c) for output of signals to a printer or display unit, indicated generally by the reference numeral 29.

The solid model definition module 30 includes a solid model definition controller 30(a) connected to a user interface 30(b) and to a database 30(c) for output of signals to a conventional solid model drawing system 31.

The user interfaces of each output module are used for input of control rules to the relevant database as well as for interactive inputs.

Operation of the design apparatus 19 is now briefly described with reference to Fig. 3. Essentially, the apparatus 19 operates in a radically different manner from conventional design systems. The design controller 21 and the design database 20 are used initially to create and store items, which may be either solid parts or empty space such as a bore or a cut-out. Thus, a designed article is made up of a number of items which are interrelated. However, the information in each item is stored separately so that each item may be regarded as a designed article in it's own right. Thus, outputs from the database may be used in a versatile manner to provide a wide range of outputs and the apparatus is not limited to output of drawing signals, as with the prior art.

The design database 20 may be regarded as a "hub" from which data may be retrieved for generation of outputs such as CNC machine control signals, a bill of materials listings, solid model definition drawings, or conventional 3-dimensional drawings. Not only is a wider range of outputs provided but the drawing outputs which are provided are considerably more versatile than heretofore. These advantages will be readily understood from the following description of operation of the apparatus in more detail.

To design a mould, a user inputs various data at the user interface 22. In step 40 the design controller 21 directs display at the user interface 22 of a list of possible mould bases, from which the user selects a particular base. A selection list is retrieved from the database 20. Once a particular base is selected, the design controller 21 locates and retrieves object hierarchies in step 41 for that particular mould base. The object hierarchies in the database 20 are in a tree structure in which parameters may be chosen depending on both control rules and user inputs where options are available. One such option, for example, is selection of the type of ejector pin to be used. In step 42 a user inputs a selection. Once this has been done, the design controller 21 in step 43 selects parameters, as illustrated in Fig. 4. This process involves both interactive inputs from the user and reference to the design database 20 and a catalogue database 23, as shown in Fig. 4. If items already stored in

the database for that particular article include ejector pins, codes are chosen to link that ejector pin item with other ejector pin items.

Other examples include user choice of the length of ejector pin in step 46 and in step 47 the design controller 21 determines if the length chosen is sufficient to reach the split plane of the mould. If not, in step 48, an appropriate length is chosen. In this embodiment, the lengths chosen are standard lengths retrieved from a catalogue 23. If the required length does not coincide with a standard length, the closest standard length which is greater than the required length is chosen. Thus, the part, when purchased, may be cut to the correct length. A user may also select a type of screw in step 49 and in step 50 the design controller 21 chooses lengths for that type of screw. The links chosen are analogous to the codes which would be used in a relational database to relate various items. In step 51, a user chooses a range of thickness for the screw and in step 52 the design controller 21, by reference to an object hierarchy in the design database 20 selects the appropriate standard thickness. In step 53, a user chooses a type of steel for a plate and in step 54 the design controller refers to the database to check if the type is allowed. Many parameters are determined for items without reference to a user in situations where user options are not available. For example, where a user selects a type of mould base, the design controller 21 immediately

creates an item defining each of the plates used because there are no user options for this particular parameter.

Making use of user inputs, reference to the catalogue databases 23 and to the design database 20, a mould design is created which comprises a large set of items including physical parts and empty spaces such as through-bores. For example, when an ejector pin item is created, the design controller 21 automatically creates an ejector pin through-bore and automatically assigns a position for the through-bore item without reference to the user. Thus, at the end of the design process the apparatus 19 stores a design in the form of a large number of items, each of which is a designed article in it's own right but is interlinked and has attributes relating it to other items to form the complete design article.

The data may be used in any desired manner. For example, for generation of drawings of the article, the drawing control module 24 is used. A user may input at the interface 24(c) an instruction as to a drawing which is required. The drawing controller 24(a) automatically retrieves the dimensions and attributes for each item which is viewed in that drawing. These parameter values are combined by the drawing controller 24(a) with data retrieved from the drawing databases 24(b). The process flow is shown in Fig. 5(a).

The views database would include various views including perspective, end and plan views and rules associated with generation of such views on receipt of the parameter values for each item. The drawings database includes rules for generation of lines by reference to the item parameter values. As each item is retrieved from the design database 20, the drawing controller 24(a) automatically inserts the item design identification code into a table and generates an associated drawing item identification code to create a cross-referencing table. This simplifies identification of items. A sample table is shown in Fig. 5(b). The drawing controller 24(a) merges data from the design database 20 and the drawing databases 24(b) to generate signals for a conventional drawing system 25. Because drawing signals which are generated are for a number of interrelated items, a user may if desired, view a single item without reference to any other items in the design. Thus, for example, a through-bore for an ejector pin may be viewed individually or a close-up drawing of a screw may be shown. Heretofore, with conventional design systems, a design is stored as a representation of a total model and parts could not be isolated without affecting the total model.

Because the design apparatus 1 stores a number of items forming the article design, other outputs may be generated. For example, the machine control module 26 retrieves parameter values for any desired item to generate CNC machine control signals according to stored machine programs. For example,

the machine controller 26(a) would determine from the dimensions of an item the type of machine programs required and would retrieve these machine programs to generate the necessary signals. Again, individual items may be machined separately because of the manner in which the design apparatus 19 operates.

Because of the links stored for each item, a bill of materials may be generated by the materials listing module 28. This involves retrieval by the materials controller 28(a) of features, attributes and links for each item to generate listings in whatever order is desired. It will be appreciated that this saves a considerable amount of lead time in article design.

Another extremely important aspect of the invention is the manner in which solid model definition drawings may be generated with relative ease. Because the designed article is formed from a number of items, the solid model definition module 30 may simply retrieve the items for solid parts for generation of the necessary control signals. It will thus be appreciated that there is a large amount of versatility and operation of the design apparatus 19 and any desired set of items may be retrieved, either solid or "empty" as desired.

It will be appreciated that in general the design apparatus 19 may be applied to a much wider field of design and production

than some presently available design systems. An article may be designed, drawings generated, solid model drawings generated if required, bills of material generated and control signals may be generated for a machine for machining of the article. This is achieved because the design apparatus of the invention operates in a relatively different way than heretofore. Heretofore, drawing lines have been inputted and combined together to form an article design. With the invention, items are defined and may be used for generation of drawings and other outputs such as machine control signals. Not only does this allow a wider application of the design apparatus 1 but in each different mode of operation, there is considerably more versatility allowed.

The invention is not limited to the embodiments hereinbefore described, but may be varied in construction and detail.

CLAIMS

1. An apparatus for design of articles, the apparatus comprising:-

a knowledge design database defining items potentially incorporated in design of an article, the database storing the item parameters including permissible dimensions, attributes, links and a description, the database further storing control rules for selection of parameters for each item;

a user interface;

a storage device;

a design controller connected to the design database, the user interface, and the storage device and comprising means for directing display at the user interface of prompts for user interactive input of item parameters; means for assigning a design identification code to each item; means for verifying user inputted parameters; and means for selecting parameters according to the design database and user inputs, and means for directing storage of selected parameters for all items for a designed article in the storage device;

a knowledge drawings database comprising stored drawing output signals associated with item parameters; and

a drawing controller connected to the design database and to the drawing database and comprising means for assigning a drawing identification code to each item cross-referenced with a design identification code, and means for converting item parameters to a drawing control output by reference to the drawing database.

2. An apparatus as claimed in Claim 1, wherein the drawing controller interactively maintains a table of identification codes for cross-referencing design and drawing identification codes for items.

3. An apparatus as claimed in Claims 1 or 2, wherein the items include both solid parts and empty space within an article.

4. An apparatus as claimed in any preceding claim, further comprising a database of machine control programs, and a machine controller comprising means for retrieving machine control programs in response to item parameters for generation of machine control signals.

5. An apparatus as claimed in any preceding claim, further comprising a database of solid model definition programs and a solid model definition controller comprising means for retrieval of items relating to solid parts and selection of the programs in response to the item parameters for generation of solid model definition signals.

6. An apparatus as claimed in any preceding claim, further comprising a database of bill of material listing data and a listing controller comprising means for retrieval of items relating to a bill of material and selection of data according to the item parameters for generation of bill of material printing signals.

7. A design apparatus substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

19

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E:.aminer's report to the Comptroller under Section 17 (The Search Report)

Application number 9110076.8

**Relevant Technical fields**

(i) UK Cl (Edition K ) G4A (AUB)

(ii) Int Cl (Edition 5 ) G06F (15/60, 15/72)

Search Examiner

B G WESTERN

**Databases** (see over)

(i) UK Patent Office

(ii)

Date of Search

20 August 1991

Documents considered relevant following a search in respect of claims 1-7

| Category (see over) | Identity of document and relevant passages | Relevant to claim(s) |
|---|---|---|
| X | GB 2190268 A (TOSHIBA) whole document | 1-6 |
| X | GB 1445914 A (IBM) whole document | 1-4,6 |
| X | GB 1317510 A (STC) whole document | 1,2, 4,6 |
| X | EP 0218246 A2 (HITACHI) whole document | 1-3 |
| X | EP 0055365 A2 (IBM) whole document | 1-4,6 |

SF2(p)

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